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# Perception of pro-environmental behavior

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ABSTRACT

Interventions to change individual human behavior have real promise in helping to reach sustainability goals and emissions reductions targets. However, little is known about how laypeople characterize the vast array of behaviors they perform that impact the natural environment, which has major implications for the design of successful pro-environmental behavior (PEB) interventions. Drawing on the psychometric paradigm from risk perception research, the current project involves a two-study investigation (Study 1: $n = 157$, Study 2: $n = 266$) into the attributes laypeople consider when evaluating PEBs and assesses the influence of these attributes on PEB intention using aggregated factor analysis. We find that laypeople's perceptions differ from experts' and include characterizations in terms of financial and behavioral cost, environmental impact and financial savings, external pressures, and health and safety impacts, with all factors except environmental impact and financial savings relating to PEB intention. Furthermore, our plots of behaviors on 2-dimensional attribute planes provide key information to researchers and policymakers about which factors to address in future PEB campaigns.

## 1. Introduction

Virtually every behavior performed by people in the developed world has environmental consequences (Gardner and Stern, 2002). Consider, for example, key elements in the morning routine of a typical worker in the suburban U.S.: wake up to an alarm set on a cell phone that has charged overnight from an electrical outlet, turn on lights powered from a coal-fired power plant, brush teeth in water running from the sink, retrieve milk from the refrigerator that runs on electricity into a cup of coffee that was farmed and shipped from somewhere else in the world, and drive to work in a car that runs on petroleum. Carbon emissions from coal-fired power plants and petroleum fuel, methane emissions from farming cows, reduction of finite water sources – as the morning routine illustrates, we are constantly performing behaviors that directly or indirectly impact the natural environment.

It is well known that widespread adoption of more environmentally friendly behaviors can have a major impact on reducing environmental impact, including mitigating climate change (Clayton et al., 2015; Dietz et al., 2009; Gardner and Stern, 2008). Yet, although environmental psychology has learned a great deal about how values, norms, and attitudes influence pro-environmental behavior (PEB) intention (Bamberg and Möser, 2007; Klöckner, 2013; Maki and Rothman, 2016; Stern, 2000), research has rarely focused on how laypeople (i.e., people who are not experts in pro-environmental behavior) think about and characterize the diverse array of PEBs. Additionally, though much research has investigated the public's perception of the environment, such as climate change perceptions (Howe and Leiserowitz, 2013; Pidgeon et al., 2008) and perceptions of environmental risks (McDaniels et al., 1995; Willis and DeKay, 2007), surprisingly little is known about laypeople's perceptions of the behaviors they perform that affect the environment. As a result, environmental policies based on experts' characterizations of PEB or assumptions about how laypeople view PEB may be ineffective because they fail to adequately account for the key PEB barriers and drivers that laypeople view as important. Thus, a deeper understanding of the layperson's nuanced perception of PEBs is required for the successful design and implementation of policies to promote PEBs. In the present project, we aim to uncover the underlying attributes laypeople view as important in considering PEBs and to assess how perceptions of PEBs in terms of these attributes relate to behavioral intention.

### 1.1. Existing PEB characterizations

Most existing research on PEB attributes has focused on energy experts' conceptualizations about the cost, frequency of action, and environmental impact of one class of PEBs: household behaviors that contribute to greenhouse gas emissions reductions (Dietz et al., 2009; Gardner and Stern, 2008; Laitner et al., 2009). Experts have most frequently proposed a simple dichotomous classification scheme (Barr et al., 2005; Black et al., 1985; Gardner and Stern, 2008; Inskeep and

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Attari, 2014; Karlin et al., 2012; Laitner et al., 2009): *efficiency-improving actions,* behaviors that involve efficiency upgrades such as buying a more fuel-efficient automobile or installing an energy-efficient clothes washer, and *curtailment actions*, behaviors that involve reducing use of existing energy equipment such as turning off the lights in a room at night or carpooling to work. Experts classify curtailment behaviors as low/no financial cost behaviors performed with high frequency and efficiency behaviors as high cost behaviors performed with low frequency (Karlin et al., 2012; Laitner et al., 2009). Furthermore, researchers have advocated for a focus on efficiency upgrades because of their higher environmental impact (Gardner and Stern, 2008). Although initial evidence suggests the lay public may also view energy behaviors in line with the curtailment/efficiency dichotomy (Barr et al., 2005; Karlin et al., 2012), in-depth analyses of laypeople's perceptions of PEBs is clearly needed considering they are the group who will be targeted in environmental campaigns.

A second class of literature has adopted a more layperson-driven approach to categorizing a wider set of PEBs, in addition to household energy behaviors. This approach typically involves conducting surveys of the public's self-reported PEB frequency and PEB intentions and then factor analyzing their responses to see which types of PEBs group together. Thus, the resultant behavior dimensions are usually organized around PEB frequency: PEBs that are performed with the same frequency are grouped together. Such analyses generally reveal different clusters of PEBs based on different domains of behavior (Barr et al., 2005; Gatersleben et al., 2002; Karp, 1996; Stern et al., 1999, 1998; Thøgersen and Olander, 2006; Whitmarsh and O'Neill, 2010) such as waste-reduction, recycling, domestic energy conservation, and activism (Karp, 1996; Stern, 2000; Whitmarsh and O'Neill, 2010). Similarly, card-sorting procedures (Bernard et al., 2009) and Rasch-type modeling efforts (Kaiser and Wilson, 2004) on PEBs have also revealed multiple domains of behavior such as waste-reduction, advocacy, consumer behavior, and recycling. Nevertheless, these analyses reveal little information about *why* certain PEBs are performed more or less frequently (Steg and Vlek, 2009) or *why* certain PEBs are grouped together in the layperson's mind.

Understanding how laypeople perceive PEBs is necessary in light of evidence that perceptions of PEBs influence PEB intention. For example, Truelove and Parks (2012) asked participants to rate the extent to which a list of 12 pro-environmental behaviors mitigated global warming and to state their intentions to perform these behaviors in the future, among other questions. Ratings of the mitigation potential of the behaviors positively correlated with intentions (Truelove and Parks, 2012). Similarly, Tobler and colleagues found that perceptions of the climate benefits of PEBs, as well as perceived costs of the PEB (in terms of financial costs, time, discomfort, and inconvenience) were strong predictors of willingness to engage in the PEBs (Tobler et al., 2012). Additionally, several studies have shown that self-efficacy beliefs and difficulty ratings of PEBs relate to PEB intention or performance (de Groot and Steg, 2007; Kaiser et al., 2005; Kaiser and Schultz, 2009). Finally, although people generally underestimate the extent to which social norms influence their behavior (Nolan et al., 2008), research has consistently shown that actual and perceived norms about other people's PEB influence individuals' intention to take these same actions (Göckeritz et al., 2010; Goldstein et al., 2008; Schultz et al., 2007). Although the research suggests that perceptions are important predictors of PEB, few studies have assessed perceptions of more than one or two behavioral attributes in the same study.

One layperson-focused study conducted in 1996 that did adopt a more in-depth approach, asked participants to evaluate a set of PEBs on 10 attributes (not including self-reported behavior frequency), such as environmental impact, frequency, and technology requirements (Bernard et al., 2009). Factor analysis on these judgments revealed three factors related to efficacy, collective nature of the behavior, and cost/technology (Bernard et al., 2009). Bernard et al.'s (2009) study provides some insight into why certain PEBs are clustered together in laypeople's perceptions, but additional work on a wider set of behavior attributes is needed. Additionally, although many PEBs in their list from two decades ago are still relevant, newer behaviors need to be evaluated, especially those relating to energy efficient appliance upgrades. Furthermore Bernard et al.'s (2009) results do not assess the extent to which the factors that emerged from the attribute factor analysis relate to behavior intention. As such, current probing is needed to understand the attributes that laypeople spontaneously consider when evaluating PEBs and the extent to which PEB perceptions relate to PEB performance. Knowing which PEB perceptions laypeople hold and which relate most to PEB performance will aid policymakers in designing programs that target these specific perceptions and increase the likelihood of policy success.

### 1.2. Psychometric paradigm

The psychometric paradigm provides a methodology by which to evaluate in-depth perceptions of objects. Although not yet applied to understand PEB, the psychometric paradigm has been widely used to assess laypeople's risk perceptions (Fischhoff et al., 1978; McDaniels et al., 1995; Slovic, 1987; Willis et al., 2005). In the traditional psychometric paradigm, participants evaluate hazards (e.g., nuclear waste, microwaves) by completing scales assessing their perceptions of the hazards on various attributes (e.g., controllability, certainty, reversibility). Sample sizes for this approach are typically between 60–125 participants (McDaniels et al., 1995; Slovic et al., 1985; Willis et al., 2005), with subsample analyses on items with as few as 11–15 responses (Slovic et al., 1985; Willis and DeKay, 2007). These responses are then aggregated across participants to obtain a mean rating for each hazard on each attribute. The aggregated attribute ratings are then factor analyzed to identify dimensions that underlie the attributes. Perceptual maps are often created to visualize how the hazards vary across multiple attribute dimensions. Finally, multiple regression analyses are conducted to assess the extent to which the attribute dimensions predict key outcomes, such as the judgment of riskiness of the hazard (Willis et al., 2005).

Applied to PEB, the psychometric paradigm would involve asking participants to evaluate a set of PEBs on various attributes (e.g., environmental benefit, difficulty, frequency of performance) and conducting an aggregated factor analysis on the attribute ratings. Regressions on these aggregated attribute ratings could then be used to predict PEB intention. Using this approach, groupings of behavior that emerge from the perceptual maps would reflect multiple PEB attributes, not just frequency of intention, which dominates current laypeople-driven categorization schemes.

### 1.3. Present studies

The present project combines and extends the expert-driven and participant-driven approaches to categorizing PEBs, while drawing on the psychometric paradigm of assessing laypeople's risk perceptions (Fischhoff et al., 1978; McDaniels et al., 1995; Slovic, 1987; Willis et al., 2005). We extend previous research in the area in three ways. First, we examine laypeople's perceptions about a wide array of features of PEBs in addition to those areas identified by experts as important (i.e., behavior frequency, domain, financial cost, and level of environmental impact (Dietz et al., 2009; Gardner and Stern, 2008; Inskeep and Attari, 2014; Karlin et al., 2012; Laitner et al., 2009; Whitmarsh and O'Neill, 2010)). Specifically, we assess key factors that have been shown to be important predictors of general PEB performance such as perceived difficulty (Kaiser and Schultz, 2009), inconvenience, discomfort, and time requirement (Tobler et al., 2012). Second, we include behaviors from a broad set of PEB, not just household energy behaviors. Third, we factor analyze behavioral attribute judgments and use these attribute factors to create an organization of behaviors along the attributes as well as to predict behavioral intention.

**Table 1**
Study 1 and 2 Pro-environmental Behaviors.

| Pro-environmental Behaviors | Domain | | Curtailment/ Efficiency |
|---|---|---|---|
| | Stern (2000) | Dietz et al. (2009) | |
| Add curtains in home to retain cool air in summer | Purchase of household goods | Weatherization | E |
| Add curtains in home to retain heat in the winter | Purchase of household goods | Weatherization | E |
| *Add insulation material to home attic* | Purchase of household goods | Weatherization | E |
| Adjust thermostat up 2 degrees in the summer | Use of household goods | Daily use behaviors | C |
| *Adjust water heater to no higher than 120 degrees F* | Use of household goods | Equipment adjustments | C and E |
| Apply insulation to heating pipes | Purchase of household goods | Weatherization | E |
| *Apply insulation to home water heater* | Purchase of household goods | Weatherization | E |
| Apply insulation to radiator | Purchase of household goods | Weatherization | E |
| Avoid buying non-local produce | Consumerism | – | – |
| Avoid buying products that are tested on animals | Consumerism | – | – |
| Boycott companies with poor ecological practices | Consumerism | – | – |
| Buy low-rolling resistance tires | Purchase of household goods | Efficient equipment | E |
| Buy products with less packaging | Consumerism | – | – |
| *Carpool* | Use of household goods | Daily use behaviors | C |
| *Caulk/weather-strip doors and windows of home* | Purchase of household goods | Weatherization | E |
| Change home HVAC air filters monthly | Use of household goods | Equipment maintenance | E |
| Check home for thermal leaks | Use of household goods | Equipment maintenance | – |
| Check toilet tank for leaks | Use of household goods | Equipment maintenance | – |
| *Choose a vegetarian meal over a beef dish* | Consumerism | – | – |
| *Choose cage-free eggs* | Consumerism | – | – |
| *Choose meat from open-pasture raised animals* | Consumerism | – | – |
| Clean refrigerator coils at least once per year | Use of household goods | Equipment maintenance | E |
| Combine errand trips to reduce mileage you drive | Use of household goods | Daily use behaviors | C |
| *Compost kitchen waste* | Waste disposal | – | – |
| Cut down on the amount you fly | – | – | – |
| *Donate to an environmental organization* | – | – | – |
| Drive economically | Use of household goods | Daily use behaviors | C |
| Eat a vegetarian diet one day a week | Consumerism | – | – |
| Get electronics repaired instead of buying new | – | – | – |
| *Get frequent tune-ups, including air filter changes* | Use of household goods | Equipment maintenance | C and E |
| Install a low-flow shower head | Purchase of household goods | Efficient equipment | E |
| *Install a renewable energy system in home* | Purchase of household goods | Efficient equipment | E |
| Install an energy-efficient heating system | Purchase of household goods | Equipment maintenance | E |
| *Install an energy-efficient refrigerator* | Purchase of household goods | Efficient equipment | E |
| Install an energy-efficient washing machine | Purchase of household goods | Efficient equipment | E |
| Install an energy-efficient water heater | Purchase of household goods | Efficient equipment | E |
| Install energy-efficient windows | Purchase of household goods | Equipment maintenance | E |
| Line dry laundry | Use of household goods | Daily use behaviors | C |
| Maintain correct tire pressure | Use of household goods | Equipment maintenance | E |
| *Move thermostat down 2 degrees in the winter* | Use of household goods | Daily use behaviors | C |
| Participate in local environmental group | Activism | – | – |
| Plant a home garden to grow fruits or vegetables | – | – | – |
| Plant a tree | – | – | – |
| Plant native plants in home garden | – | – | – |
| Print double-sided | Use of household goods | Daily use behaviors | C |
| Pull refrigerator at least 4 inches away from wall | Use of household goods | Equipment adjustments | – |
| Purchase clothing from second-hand stores | Consumerism | – | – |
| Recycle electronics (such as batteries or cell phones) | Waste disposal | – | – |
| *Recycle glass* | Waste disposal | – | – |
| Recycle paper products | Waste disposal | – | – |
| *Reduce highway speed from 70 to 60 mph* | Use of household goods | Daily use behaviors | C |
| Reduce the number watering days for home lawn | Use of household goods | – | – |
| Reduce the use of synthetic fertilizers on home lawn | – | – | – |
| *Replace current vehicle with a fuel-efficient vehicle* | Purchase of household goods | Efficient equipment | E |
| Shut down computer at night | Use of household goods | Daily use behaviors | C |
| Sign a petition about an environmental issue | Non-activist public | – | – |
| *Switch to energy-efficient light bulbs* | Purchase of household goods | Efficient equipment | C and E |
| *Take a shower shorter than 5 minutes* | Use of household goods | Daily use behaviors | C |
| *Take part in a protest about an environmental issue* | Activism | – | – |
| *Turn off car if idling longer than 30 seconds* | Use of household goods | Daily use behaviors | C |
| Turn off ceiling fan when not in use | Use of household goods | Daily use behaviors | C |
| *Turn off lights when not in use* | Use of household goods | Daily use behaviors | C |
| *Turn off the tap while brushing teeth* | Use of household goods | Daily use behaviors | C |
| *Unplug television when not in use* | Use of household goods | Daily use behaviors | C |
| Use a reusable container for drinks | – | Daily use behaviors | – |
| Use environmentally friendly cleaning products | Consumerism | – | – |
| Use cold wash/rinse settings for washing machine | Use of household goods | Equipment adjustments | C |
| Use only reusable shopping bags | – | Daily use behaviors | – |
| *Use paper products made from recycled material* | Consumerism | – | – |
| *Vote for pro-environmental policy* | Non-activist public | – | – |
| Wait until clothes washing machine is full before use | Use of household goods | Daily use behaviors | C |
| *Wait until dishwasher is full before running* | Use of household goods | Daily use behaviors | C |

(*continued on next page*)

**Table 1** (*continued*)

| Pro-environmental Behaviors | Domain | | Curtailment/ Efficiency |
|---|---|---|---|
| | Stern (2000) | Dietz et al. (2009) | |
| *Walk/cycle instead of driving to places within 1 mile* | Use of household goods | Daily use behaviors | C |
| *Write to gov't official about an environmental issue* | Activism | – | – |

*Note.* Behaviors in italics were included in both Studies 1 and 2.

In keeping with the psychometric approach, in Study 1, we identified relevant attributes of PEB through a review of attributes proposed in the literature by energy experts and an open-ended survey of laypeople's perceived barriers and motivations to performing PEBs (Mckenzie-Mohr, 2000). We then used results from Study 1 to inform the development of closed-ended questions for Study 2, where a second sample of laypeople rated 74 PEBs on 21 attributes. We aimed to answer the following questions in this project:

1) What are the underlying dimensions of PEB as determined from laypeople's perceptions?
2) How are PEBs characterized in terms of these dimensions?
3) To what extent do laypeople's characterizations relate to behavior intention?

## 2. Study 1

### 2.1. Method

#### 2.1.1. Participants

Adults in the U.S. were recruited to participate in a Qualtrics survey through Amazon's Mechanical Turk (MTurk) in exchange for $0.50. MTurk participants are often used in social science research and provide rapid, high-quality, and inexpensive data (Buhrmester et al., 2011; Paolacci et al., 2010). Individuals self-select into MTurk's pool to complete tasks that are posted by requesters. The task in the current study was described as an investigation of how people perceive behaviors. The only specific qualification for participation was that participants were located in the U.S. Although 237 individuals began the survey, 63 surveys were submitted without responding to any of the open-ended questions, and 18 were submitted with less than 20% of the survey completed. These unfinished surveys were excluded from the sample and the resulting sample size was 157. No demographic differences were observed between individuals included in the final sample and those who were excluded.

Our final sample consisted of 57.3% women ($n$ = 90). Participants' mean age was 37 years old and ranged from 21 to 71. Median income level was between $35,000 and $49,999. A large majority of our sample had either obtained a bachelor's degree or completed some college ($n$ = 102), which is greater than what would be expected from a sample representative of the U.S. population. Additionally, African-Americans were under-represented in this sample compared to the U.S. population. Both Democrats, which were nearly 40% of the sample, and Independents outnumbered Republicans. Our sample was relatively evenly split between homeowners and renters with very few being neither.

#### 2.1.2. Procedure and materials

After clicking a link to an on-line survey, participants were prompted with a screen providing information about the study and informed consent to participate in the study was obtained. All individuals who agreed to participate then completed a demographics questionnaire. Next, participants were asked to answer open-ended questions about a series of PEBs. The questions elicited perceptions of PEBs with a focus on perceived barriers and benefits to behavior performance. This project was approved by the IRB at the first author's university.

*2.1.2.1. PEB list.* We created a list of 130 PEBs for potential inclusion in the study based on a review of the energy conservation and environmental psychology literature (Attari, 2014; Attari et al., 2010; Barr et al., 2005; Black et al., 1985; Dietz et al., 2009; Gardner and Stern, 2008; Gatersleben et al., 2002; Harland et al., 1999; Karlin et al., 2012; Karp, 1996; Laitner et al., 2009; Larson et al., 2015; Poortinga et al., 2004; Toner et al., 2012; Truelove and Parks, 2012; Van der Werff et al., 2014; Vandenbergh et al., 2008; Whitmarsh and O'Neill, 2010). To ensure coverage across various types of PEB, we coded each behavior according to dimensions identified in the previous literature including: domain, frequency of performance, financial cost, and environmental impact. We also noted how many previous research studies had measured the behavior. Then, we organized behaviors based on their domain and assessed how they varied in terms of the other dimensions. Specifically, we looked at how behaviors varied in terms of cost, frequency of performance, and environmental impact within each of the following behavioral domains: activism, transportation, eating, efficiency upgrades, curtailment, weatherization, waste reduction, and water conservation. Then, we selected 30 PEBs from this list that varied across these dimensions (Table 1). When deciding between behaviors that were equally variable on all dimensions, we opted to select those that had been most frequently included in previous research. Each participant was randomly assigned some of these 30 PEBs to evaluate. The first 34 participants who completed the study evaluated 10 behaviors. After receiving complaints from participants about survey length, we asked the rest of the participants to evaluate 5 behaviors.

*2.1.2.2. Perceptions of PEBs.* To assess perceptions of PEBs, we asked participants to answer three open-ended questions about each assigned behavior. The three items measured participants' perceptions about (1) the purpose of the PEB (i.e., the reason why someone would perform the behavior), (2) the barriers that prevent someone from doing the behavior, and (3) the facilitators of the behavior (i.e., what makes the behavior more likely to occur) (cf. Mckenzie-Mohr, 2000). Responses were coded as to whether they contained words related to attributes that previous researchers have identified (e.g., financial cost, difficulty, frequency) and additional categories were developed for responses that did not fall into the predetermined categories. No limits were set for how many categories a response could be coded under. Two raters coded the content of each response. To determine which attributes mentioned by participants in Study 1 would inform the development of attribute items in Study 2, we calculated the proportion of responses that were coded for each attribute. Attributes that were mentioned in at least 10% of total responses or at least 10% of responses for individual behaviors were selected for use in Study 2. Percent agreement between raters ranged from 88.75% and 98.96% with the exception of environmental impact, which had a percent agreement of 73.13%. In cases of disagreement, Coder 1's coding was used.

### 2.2. Results

Results of Study 1 showed that when asked to evaluate the purpose, barriers, and facilitators of a list of PEBs (Table 1) in an open-ended

**Table 2**
Attribute and Dependent Variable Scale Items.

| Attribute | Wording of Survey Question | Scale Endpoints | |
|---|---|---|---|
| | | Low (1) | High (9) |
| Animal Welfare[b] | If you did this behavior, how much of a positive impact would it have on the well-being of animals? | No impact | Very large impact |
| Behavior Intention[a] | How likely is it that you will do this behavior within the next 6 months? | Extremely unlikely to do it | Extremely likely to do it |
| *Cold Weather Influences* | If you did this behavior, how much would cold weather encourage or discourage you? | Strongly discourage | Strongly encourage |
| *Descriptive Norm*[b] | How many of your friends and family members do this behavior? | None of them | All of them |
| *Difficulty*[b] | If you did this behavior, how easy or difficult would it be? | Very difficult | Very easy |
| Discomfort | If you did this behavior, how would it affect your discomfort? | Not at all | Greatly increases discomfort |
| Environmental Impact | If you did this behavior, how much of a positive impact would it have on the environment overall? | No impact | Very large impact |
| *Environmental Knowledge* | How confident are you that you are aware of the environmental impacts of this behavior? | Not at all confident | Completely confident |
| Financial Cost | How financially costly is this behavior? | Not at all costly | Very costly |
| Financial Savings | How much financial savings would result from doing this behavior? | No savings at all | Very large amount of savings |
| Forgetability | If you decided to engage in this behavior in the future, how likely would it be for you to forget to do it? | Extremely unlikely to forget | Extremely likely to forget |
| Frequency | How frequently is this behavior done by people who do this behavior? | Very infrequently | Very frequently |
| Habit[b] | If you did this behavior, how easy or difficult would it be for it to become part of your routine? | Very difficult | Very easy |
| Health Impact | If you did this behavior, what impact would it have on your health? | Very harmful | Very beneficial |
| *Hot Weather Influences* | If you did this behavior, how much would hot weather encourage or discourage you? | Strongly discourage | Strongly encourage |
| *Inconvenience* | If you did this behavior, how convenient or inconvenient would it be? | Very inconvenient | Very convenient |
| *Injunctive Norm* | How much do your family and friends encourage or discourage you to do this behavior? | Strongly discourage | Strongly encourage |
| Past behavior[a] | Indicate the best estimate of how often you have engaged in this behavior in the past. | Never | One or more times per day |
| *Procedural Knowledge*[b] | How much knowledge do you have about how to do this behavior? | No knowledge | A great deal of knowledge |
| Safety | If you did this behavior, how unsafe or safe would it make you feel? | Very unsafe | Very safe |
| *Self-efficacy*[b] | How capable are you of performing this behavior? | Completely incapable | Completely capable |
| *Structural Influences* | If you did this behavior how much would existing structural conditions (e.g. local infrastructure, city or state services, laws/regulations) help or hinder you? | Greatly hinders | Greatly helps |
| Time | If you did this behavior, how much time would it take? | Very little time | Very large amount of time |

*Note*: Scales in italics were reversed scored.
[a] Scales were used as dependent variables.
[b] Items were omitted from analyses due to high multicollinearity or Heywood cases.

questionnaire format, laypeople forwarded 17 attributes that they deem as salient (listed in order of decreasing frequency of being mentioned by participants): financial cost, financial savings, environmental impact, ignorance (i.e., the degree to which a behavior is known about), time, inconvenience, health impact, structural influences, effect of material quality (i.e., impact on the quality or value of material goods), safety impact, proneness to social pressures (e.g., descriptive norm, media influence, general pressure from society), self-efficacy, animal welfare, weather influence, discomfort, habit, and "forget-ability" (i.e., tendency to forget to perform behavior).

Several findings emerged. First, a number of attributes that have not been previously used to characterize PEB emerged from the analysis: health impacts, structural influences, and safety influences. Second, behavior frequency, an attribute that has been repeatedly discussed in expert analyses (Karlin et al., 2012) was not explicitly mentioned by our participants. Third, we found evidence of the potential multi-dimensionality of PEB attributes. For example, though our participants rarely used the word 'difficult' to describe PEB, other more specific attributes (e.g., efficacy, structural influences, inconvenience) related to the overarching construct of difficulty were forwarded, suggesting that the numerous attributes of PEB may be explained by a fewer number of underlying dimensions.

## 3. Study 2

### 3.1. Method

#### 3.1.1. Participants

Adults in the U.S. were recruited to participate in a Qualtrics survey through Amazon Mechanical Turk in exchange for $1.00. The task was described as an investigation of how people perceive behaviors. The only specific qualification for participation was that participants were located in the U.S. Out of the 301 individuals who began the survey, 31 failed to complete the PEB attribute measures. These incomplete surveys were excluded from the analyses in addition to those with survey completion times greater than two standard deviations above the mean. The resulting sample size was 266.

A minority of participants, though having completed the PEB attribute measures, did not complete all demographic questions. Our sample was 58.6% women ($n$ = 156). Participants' age ranged from 18 to 70 with a mean of 36. The median income level fell between $35,000 and $49,999. Similar to Study 1 and what would be expected from an MTurk sample (Buhrmester et al., 2011; Paolacci et al., 2010), participants were more educated compared to the U.S. population, with 68.4% having attended some college or possessing either an associate's or bachelor's degree. A majority of the sample (56.8%) identified as Democrats.

#### 3.1.2. Procedures and materials

After consenting to participate in the research, participants were asked to rate 74 PEBs on two attribute items (described below) and one self-reported behavior frequency measure, with both the attribute and behavior items randomly assigned. Additional measures included in the survey but not analyzed in the present study assessed environmental concern, environmental values, environmental self-identity and global warming beliefs. On average, each PEB was rated on a given attribute by 25 participants (min. = 14, max = 36).

*3.1.2.1. PEBs.* The 74 PEBs used in this study included the 30 PEBs included in Study 1 plus 44 additional behaviors taken from the larger

list of 130 PEBs developed in Study 1 (Table 1). Following the procedure we adopted for selecting behaviors for Study1, we selected the behaviors for Study 2 by first organizing behaviors by domain and then selecting behaviors that varied in terms of cost, frequency of performance, and environmental impact. This expanded set of PEBs was meant to represent as diverse and comprehensive a list as possible, while still maintaining feasibility for participants.

*3.1.2.2. Attributes of PEB*. We used the results from Study 1 and our review of previous literature to develop a list of 21 relevant attributes of PEB (Table 2). Seventeen of these attributes were identified through Study 1 (see results of Study 1), few of which overlapped with those studied in previous literature (e.g., financial cost, environmental impact), and the following four were drawn exclusively from the literature: descriptive norms, injunctive norms, behavioral frequency, and difficulty. Participants' perceptions about the following attributes of PEBs were measured on semantic differential scales with values from 1 to 9 that assed the following parameters: financial cost, difficulty, frequency, inconvenience, time, discomfort, environmental impact, financial savings, health impact, habit, environmental knowledge, structural influences, safety, hot and cold weather influences, descriptive and injunctive norms, self-efficacy, animal welfare, procedural knowledge, and "forget-ability" (i.e., likelihood of being forgotten). Items were reverse-scored in cases in which the negative dimension (i.e., lower scores) of the attribute represents a barrier to behavior. Items in which the positive dimension of the attribute already represented a barrier (e.g., discomfort, financial cost) or the attribute represented a benefit of the behavior (e.g., environmental impact, financial savings, animal welfare) were not reverse-scored.

*3.1.2.3. Self-reported behavior frequency*. Two items were used to measure self-reported behavior with one item measuring past behavior and one measuring future intention. Response options for the past behavior item 'Please indicate the best estimate of how often you have engaged in this behavior in the past' were 'Never', 'Less frequently than once per year', 'Once per year', 'Once every six months', 'Once every three months', 'One or more times per month', 'Once per week', 'Multiple times per week', and 'One or more times per day.' A 1 (extremely unlikely to do it) to 9 (extremely likely to do it) scale was used to measure behavior intention on the item 'How likely is it that you will do this behavior within the next 6 months?'

### 3.2. Results

#### 3.2.1. Factor analysis of PEB attributes

Using the participant-elicited attributes revealed in Study 1 as well as a review of the literature on expert conceptualizations of PEB, in Study 2 we created a list of 21 behavior attributes (Table 2) on which subsets of U.S. participants recruited from Amazon's Mechanical Turk pool rated 74 PEBs (McDaniels et al., 1995; Willis et al., 2005) (Table 1). Following the psychometric approach (McDaniels et al., 1995; Slovic et al., 1980), we conducted an aggregate-level factor analysis of item inter-correlations, calculated from responses aggregated across individuals using maximum likelihood with promax rotation (c.f., Willis and DeKay (2007) who performed aggregated factor analyses with subgroups ranging from 11 to 16 participants and who found similar results across subgroups). We omitted six attributes (i.e., animal welfare, habit, difficulty, descriptive norm, self-efficacy, and procedural knowledge) due to high multicollinearities (model determinants < .00001 and correlations with other variables > .73) or a factor loading greater than 1 with a negative residual variance (Heywood case). Four factors with eigenvalues greater than 1.0 emerged from the analysis as the most interpretable solution, with the factors explaining 73% of the total variance in mean attribute ratings.

Results from the aggregate-level factor analysis on behavior attributes are shown in Table 3. First, the 15 behavior attributes loaded on four main dimensions. Second, frequency of action and financial cost, the main dimensions identified by experts as two separate dimensions of PEB, were seen by laypeople as part of the same factor, *financial and behavioral cost*, with frequency of action negatively correlating with financial cost. Thus, whereas energy experts often focus on cost in strictly financial terms, lay participants seem to bundle financial and behavioral costs together and view behaviors in terms of their cost more generally without distinguishing between financial and behavioral costs. Third, *environmental impact and financial savings* emerged as a distinct factor from financial and behavioral cost meaning that laypeople perceive that behaviors can have both financial costs and savings, such as an energy efficiency upgrade having both upfront investment costs and long term monetary savings. Fourth, two new factors, not identified in previous characterizations of PEB emerged: *external pressures* including norms, cold weather, discomfort, and structural influences; and *health and safety impacts* including safety concerns and health impacts, suggesting that current expert conceptualizations of PEBs may be missing key considerations of laypeople. All factors were moderately to highly inter-correlated with the exception of *financial and behavioral cost* (Factor 1) and *environmental impact and financial savings* (Factor 3), which had a correlation near zero.

**Table 3**
Rotated Pattern Matrix from Aggregate-Level Factor Analysis of Attribute Scales.

| Attribute | Factor 1 Financial and Behavioral Cost | Factor 2 External Pressures | Factor 3 Environmental Impact and Financial Savings | Factor 4 Health and Safety Impact |
|---|---|---|---|---|
| Frequency | **−.906** | .188 | .174 | .029 |
| Cost | **.891** | −.295 | .097 | .128 |
| Time | **.845** | .064 | .222 | .184 |
| *Inconvenience* | **.703** | .466 | .013 | .017 |
| Discomfort | −.034 | **.995** | .291 | −.063 |
| *Cold Weather* | −.231 | **.753** | −.106 | .242 |
| *Structural Influences* | −.094 | **.649** | −.263 | .215 |
| *Injunctive Norm* | .218 | **.504** | −.246 | −.172 |
| Environmental Impact | .077 | .073 | **.932** | .034 |
| Financial Savings | .104 | −.056 | **.743** | −.207 |
| *Environmental Knowledge* | .157 | .029 | **−.578** | −.391 |
| Safety | .022 | −.081 | −.141 | **.894** |
| Health Impact | .202 | .238 | −.062 | **.633** |
| Hot Weather | −.131 | .385 | −.043 | −.387 |
| Forget-ability | .084 | .349 | −.366 | .112 |
| *Interfactor correlations* | | | | |
| Factor 2 | .297 | | | |
| Factor 3 | −.009 | −.499 | | |
| Factor 4 | −.383 | −.580 | .571 | |

*Note*. Attributes in italics are reverse scored. Loadings greater than |.500| are in bold text.

#### 3.2.2. Using PEB perceptions to predict behavior intention

To assess the usefulness of the four factors of PEB attributes in predicting behavioral intention, we regressed the mean ratings for the behavior intention measure (aggregated across all participants) onto the PEB perception factor scores. The four factors as a set explained 88% of the total variance in behavior intention, $F$ (4, 73) = 120.22, $p < .001$. As expected, greater willingness to engage in PEB was associated with perceptions of lesser costliness (Factor 1), $\beta = -.61$, $p < .01$, and greater encouragement by external pressures (Factor 2), $\beta = -.33$, $p < .01$, when controlling for the other factors in the model. Additionally, the more participants perceived PEBs as having positive health and safety impacts (Factor 4), the more likely they were to engage in PEBs, $\beta = .23$, $p < .05$. However, perceptions of environmental impact and financial savings (Factor 3) did not predict PEB intention, $\beta = .001$, $p > .05$.

**Table 4**
Factor Scores for the Five Highest and Lowest Scoring PEBs for the Four Factors of PEB Perceptions.

| Factor 1 | | Factor 2 | | Factor 3 | | Factor 4 | |
|---|---|---|---|---|---|---|---|
| Financial and behavioral cost | | External pressures | | Environmental impact and financial savings | | Health and safety impact | |
| Renewable energy system | 2.43 | Protest about environmental issue | 2.46 | Energy-efficient heating system | 1.73 | Turn off lights when not in use | 1.62 |
| Fuel-efficient vehicle | 2.29 | Participate in environmental group | 2.14 | Renewable energy system | 1.71 | Plant a tree | 1.55 |
| Energy-efficient windows | 1.89 | Line dry laundry | 1.85 | Turn off lights when not in use | 1.67 | Maintain correct tire pressure | 1.47 |
| Energy-efficient heating system | 1.81 | Unplug television when not in use | 1.74 | Energy-efficient windows | 1.16 | Plant a fruit/vegetable garden | 1.34 |
| Insulation material in attic | 1.48 | Avoid buying non-local produce | 1.71 | Energy-efficient light bulbs | 1.14 | Recycle paper products | 1.34 |
| Recycle paper products | −1.29 | Turn off ceiling fan when not in use | −1.17 | Participate in environmental group | −1.65 | Buy low-rolling resistance tires | −1.60 |
| Use a reusable drink container | −1.33 | Curtains to retain heat in winter | −1.48 | Donate to organization | −1.84 | Apply insulation to radiator | −1.72 |
| Turn off tap while brushing teeth | −1.34 | Curtains to retain cool air in summer | −1.49 | Protest about environmental issue | −1.84 | Purchase second-hand clothing | −2.05 |
| Turn off ceiling fan when not in use | −1.52 | Turn off lights when not in use | −1.52 | Sign petition about environmental issue | −2.18 | Write to gov't official | −2.40 |
| Turn off lights when not in use | −2.02 | Energy-efficient light bulbs | −1.61 | Write to gov't official | −2.32 | Protest about an environmental issue | −3.10 |

### 3.2.3. PEBs by attributes

To zero in on how laypeople conceptualize PEBs according to the identified dimensions, we identified the 5 highest and 5 lowest scoring PEBs on each of the four factors (Table 4). As expected, the PEBs scoring highest on financial and behavioral cost are energy-efficiency upgrades and the PEBs scoring lowest on financial and behavioral cost are common curtailment behaviors. Curtailment behaviors (those related to household heating and cooling and light bulb use) are also among the PEBs most encouraged by external pressures, while activism-type behaviors like writing to a government official and signing a petition are most discouraged by external pressures. Interestingly, activism-type behaviors were also perceived as having the lowest environmental impact and financial savings. Behaviors perceived as having the greatest environmental impact and financial savings include both efficiency and curtailment behaviors, which is at odds with most expert analyses showing efficiency upgrades as having the most environmental impact. Having the lowest perceived health and safety impacts are activism behaviors, especially protesting, in addition to purchasing second-hand clothing, and insulating one's radiator. Behaviors perceived as highest in health and safety impacts are gardening/home lawn behaviors like planting a tree and a home garden along with maintaining correct car tire pressure.

### 3.2.4. PEB perception maps

We created perception maps plotting each of the 74 PEBs on two-dimensional planes relating to different combinations of the four factors, which provide a multifaceted view of layperson conceptualizations. Fig. 1 displays the relative orientation of the 74 PEBs in terms of financial and behavioral cost (Factor 1; horizontal axis) and external pressures (Factor 2; vertical axis). Of note, energy efficiency upgrades are generally seen as high in financial and behavioral cost, yet encouraged by external pressures (lower right quadrant), while curtailment behaviors are generally seen as low in financial and behavioral costs, and neither strongly encouraged or discouraged by external pressures (left two quadrants). Activism-type behaviors and some food-related behaviors are seen as high cost and discouraged by external pressures (top right quadrant).

Fig. 2 shows laypeople's characterization of PEBs in terms of the two factors experts generally see as most important: financial and behavioral cost (Factor 1; horizontal axis) and environmental impact and financial savings (Factor 3; vertical axis). Efficiency upgrades are seen as being high in both environmental impact and financial savings and financial and behavioral cost (upper right quadrant), while curtailment behaviors are mostly seen as low in financial and behavioral costs and high in environmental impact and financial savings (top left quadrant). Activism-type behaviors are generally seen as high in financial and behavioral cost and low in environmental impact and financial savings (bottom right quadrant). Additionally, domain-specific clustering is evident here. Two-dimensional maps for all other combinations of factors are displayed in Figs. S1–S4.

## 4. Discussion

The application of the psychometric paradigm to understanding PEB in this study provides one of the most in-depth analyses to date of laypeople's perceptions of PEB. The results reveal several new findings that underscore differences between laypeople and experts' conceptualizations of PEBs, including multiple new factors that have not been identified by expert analyses of PEBs. Furthermore, the results offer insight into potential leverage points for future PEB interventions.

Experts often think of curtailment behaviors as problematic for the public because of the behavioral costs of repeating the action daily or weekly (Gardner and Stern, 2008). However, our results suggest that laypeople do not view behaviors that have to be performed frequently as particularly inconvenient or time-consuming. Instead, frequency was negatively related to inconvenience and time, while monetary cost was positively associated with inconvenience and time. Therefore, PEBs that have a large financial cost, such as efficiency upgrades, are actually seen as more inconvenient and time-consuming, even though experts often laud the fact that these actions do not have to be repeated as a benefit of these behaviors (Gardner and Stern, 2008; Karlin et al., 2012). Laypeople's view of high cost PEBs is most likely due to the initial time needed to research efficiency upgrades and meet with vendors who can perform the actions, while their view of high frequency behaviors as low in inconvenience and time could mean that laypeople, like some researchers, see curtailment behaviors as habitual (Barr et al., 2005). On a related note, financial cost and behavior frequency loaded onto the same factor, which suggests that two of the major characteristics by which experts distinguish behaviors were seen as a single dimension by our sample of laypeople. Thus, although laypeople appear to agree with experts that high cost PEBs are also low in frequency, there may not be a need to consider both attributes in characterizing PEBs as participants view them as inseparable.

Findings also revealed a factor related to environmental impact and financial savings, which shows that laypeople, at least to some extent, view PEBs in terms of their environmental impact. However, some misperceptions are evident when evaluating the list of behaviors that are ranked most highly and low on this dimension. Specifically, although several efficiency upgrades were rated as having the most environmental impact and financial savings, turning off the lights when

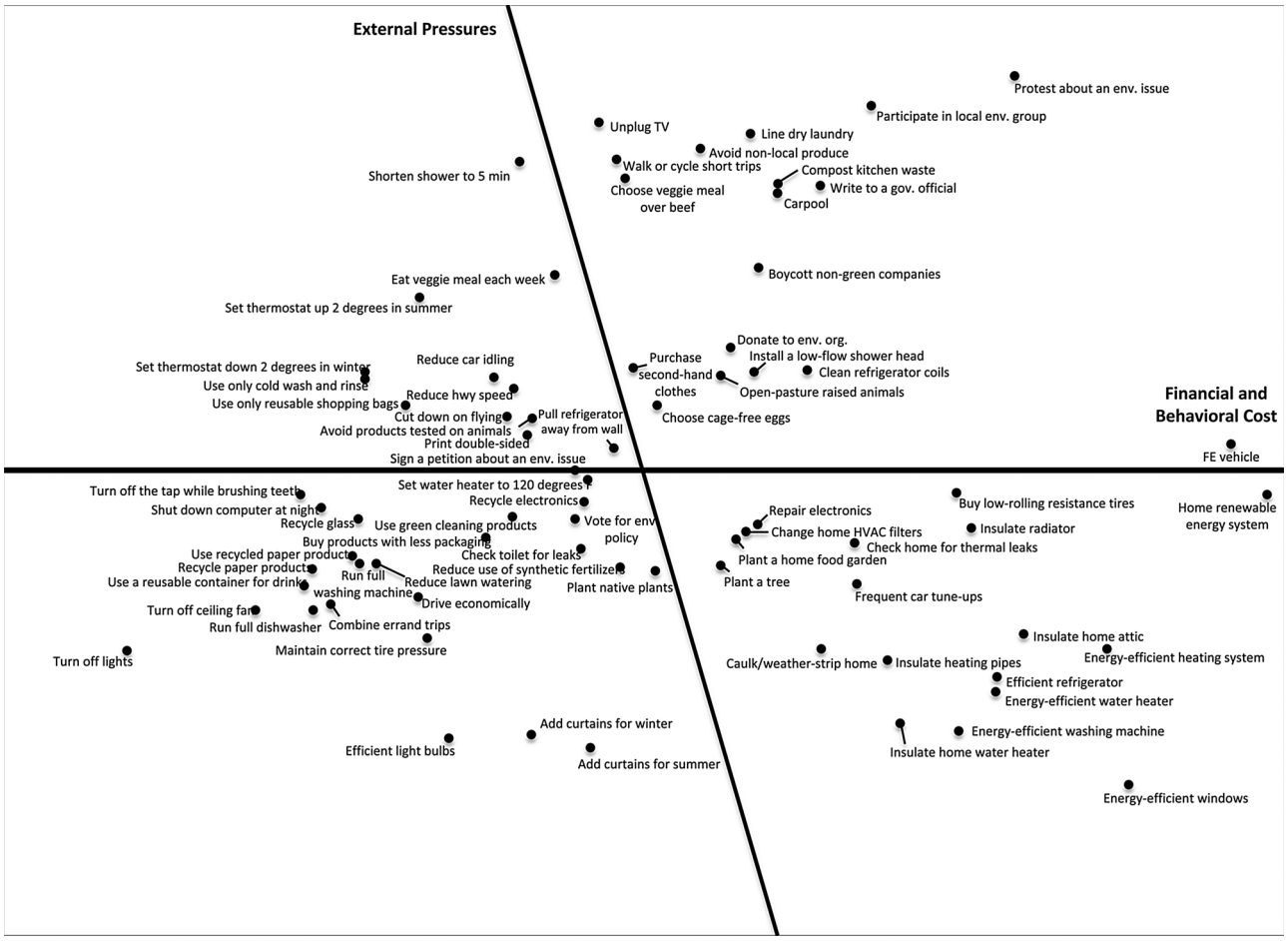


**Fig. 1.** Aggregate-level factor scores of pro-environmental behaviors characterized by Financial and Behavioral Costs (Factor 1) and External Pressures (Factor 2). Angle of the axes is reflective of the correlation between the factors.

not in use, a common curtailment behavior, was rated as the third highest behavior on the environmental impact and financial savings, when this behavior actually saves much fewer emissions than household efficiency upgrades (Dietz et al., 2009; Gardner and Stern, 2008). Additionally, political PEBs, which undoubtedly can have a large indirect effect on the environment, were consistently rated in the bottom in terms of environmental impact and financial savings. These findings confirm previous research showing that laypeople do not have a clear understanding of the environmental implications of many common PEBs (Attari et al., 2010; Truelove and Parks, 2012).

The environmental impact and financial savings factor is also interesting in that it emerged in addition to the financial and behavioral costs factor. Thus, laypeople recognize that PEBs can have both up-front behavioral and financial costs as well as long-term financial and environmental benefits. In our results, many of the PEBs rated as scoring the highest on financial and behavioral cost also score the highest on environmental impact and financial savings. Investment programs such as those that subsidize household efficiency upgrades would do well to leverage this finding and remind the public of the long-term financial and environmental benefits of these upgrades. At the same time, although most of the attribute factors that emerged from the aggregate factor analysis were intercorrelated, the financial and behavioral cost factor was nearly orthogonal with the environmental impact and financial savings factor. Thus, although experts commonly view PEBs in terms of positively related factors of financial cost and environmental impact (e.g., efficiency upgrades as high in both financial cost and environmental impact and curtailment behaviors as low in both financial cost and environmental impact (Gardner and Stern, 2008)), our sample of laypeople did not make this connection. This is further evidenced by the ratings of PEBs along the dimensions. Efficiency upgrades consistently received high ratings for cost and environmental impact, but curtailment behaviors received divergent ratings on the two factors. For example, turn off the lights when not in use was rated the lowest of all PEBs on financial and behavioral cost and among the highest on environmental impact and financial savings. This suggests that some of this misalignment between experts and laypeople may be due to misperceptions of the environmental impact of curtailment behaviors, which is in line with previous research (Truelove and Parks, 2012).

Our findings also revealed a new dimension related to external pressures to perform PEBs. We know a great deal about how social norms influence us and, particularly in the environmental field, norm interventions have been successful at changing behavior (Bergquist and Nilsson, 2016; Schultz et al., 2007). Even in the face of research showing that people underestimate the effect social norms have on them (Nolan et al., 2008), it is clear from our results that laypeople recognize that different PEBs are more or less encouraged by their friends and families, suggesting that PEB uptake may follow along social networks. In addition to these social pressures, participants characterized PEBs in terms of the structural pressures surrounding the physical environment in which the PEB is performed. Researchers have long argued for the importance of structural solutions to environmental problems (van Vugt et al., 1996), yet the physical environment has rarely been included in experts' conceptualizations of PEB.

Our results revealed another new dimension: health and safety impacts. Research on PEBs has begun to cross over to investigate simultaneous health concerns and outcomes (Pretty et al., 2007), yet expert characterizations of PEBs have not included this dimension.

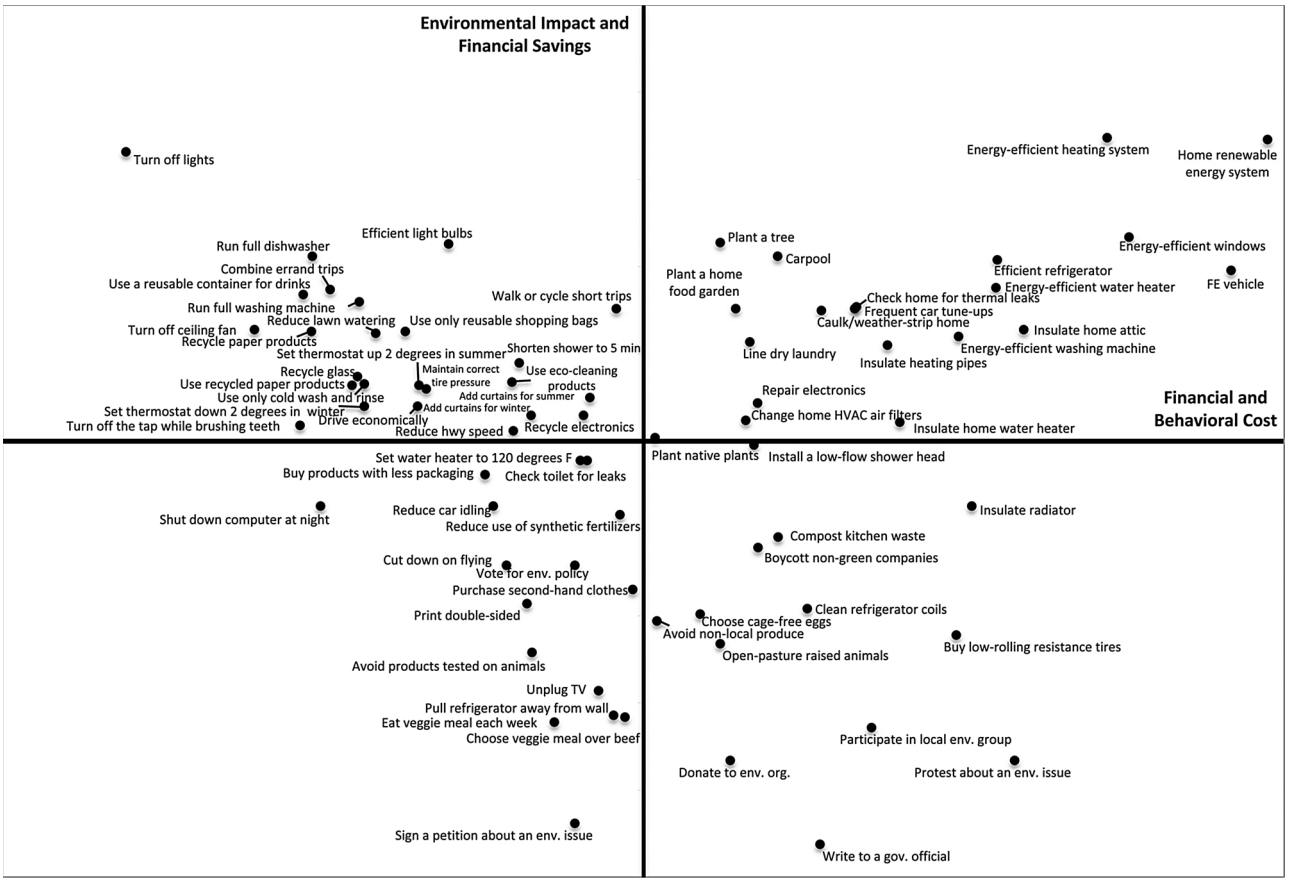


**Fig. 2.** Aggregate-level factor scores of pro-environmental behaviors characterized by Financial and Behavioral Costs (Factor 1) and Environmental Impact and Financial Savings (Factor 3).

Furthermore, safety impacts of PEBs have been largely ignored by experts. That our sample of laypeople identified health and safety impacts as a unique dimension of PEB is noteworthy and harkens back to Slovic's work on lay perception of risk showing that the public often has perceptions that are unexpected (Slovic, 1987). Nevertheless, knowing that laypeople characterize PEBs in terms of health and safety impacts suggests that pointing to the health co-benefits of PEBs could be a useful strategy for encouraging these behaviors.

Our results also highlight how laypeople's perceptions of PEB relate to intention to perform these behaviors. Though perceptions of financial and behavioral cost were found to be the strongest predictor of PEB intention, external pressures and health and safety impacts also significantly relate to PEB intention, while environmental impact and financial savings do not, suggesting that simply educating the public about the environmental benefits of a behavior is not an effective strategy. Thus, campaigns to increase PEBs could benefit from focusing on dimensions beyond cost and environmental impact to address other key features of laypeople's perspectives, such as external pressures and health and safety impacts. The current results provide an additional set of potential entry points for future interventions to increase sustainable behaviors.

Although previous layperson-driven analyses of PEB have shown domain-specific clustering such that people behave inconsistently across domain areas (Steg and Vlek, 2009), the perceived attributes of behavior identified in this study provide insight into *why* this is the case. Knowing the perceived barriers and benefits of a PEB and developing interventions to specifically target these barriers and benefits can greatly increase the likelihood of success of behavior change programs (Schultz, 2014). Furthermore, as policymakers strive to achieve positive spillover between their interventions' targeted behavior and non-targeted behaviors (Truelove et al., 2014), knowledge of the perceived common barriers or facilitators of various PEBs, information gleaned in this study, will be paramount.

The current results were obtained from a sample of 266 U.S. residents recruited from Amazon's Mechanical Turk site, which is not considered a representative sample of the U.S. public. Studies done using the psychometric paradigm to investigate risk perception typically use relatively small samples due to the time it takes to complete the tasks. The sample used in the current study is larger and arguably more diverse than those used in previous studies on risk perception that use the psychometric approach, which often include samples of fewer than 100 participants and draw heavily on undergraduate students or members of specific stakeholder groups (Fischhoff et al., 1978; McDaniels et al., 1995; Willis et al., 2005; Willis and DeKay, 2007). Importantly, there is evidence that the factor patterns that emerge from using the psychometric paradigm to investigate risk perception among small samples are replicable across layperson groups (Slovic et al., 1985; Willis and DeKay, 2007). Considering this is the first study to apply this paradigm to understand PEB, future work should replicate this approach with multiple samples including experts and randomly selected members of the U.S. population.

### 4.1. Conclusions

A focus on the expert perspective of PEB has directed our attention selectively toward certain attributes (e.g., cost, frequency, and environmental impact) and away from others (e.g., social pressures, health impacts, and structural influences) resulting in a sort of "conceptual blind spot" as to what might actually explain PEB (Stern, 1986) and where interventions should target their efforts. Our analysis using the psychometric paradigm of risk perception (Slovic et al., 1982, 1980) moves us toward a better understanding of laypeople's perceptions of

PEB across a wide variety of dimensions. Our results show that laypeople's perceptions are more complex than simple concerns of behavior cost and environmental impact, but include additional dimensions related to external pressures and health and safety impacts.

## Author Contributions

HBT and AJG designed the study, analyzed the data, and wrote the manuscript.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.gloenvcha.2018.02.009.

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